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EFFECT OF INJECTION PRESSURE ON A DIESEL ENGINE USING PYROLYSIS BIO-OIL FROM SPIRULINA ALGAE

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ABSTRACT

Algae biomass is newly considered to be a higher source of energy. In algae, the energy is stored as oils and carbohydrates, with that have higher productivity. The production can be about 2000 to 5000 gallons of biofuels in one year. Algae have become a dependable source for bio-oil production all through Pyrolysis. The bio-oil be obtained from the process of heating the spirulina algae at the maximum temperature of 200 °C to 350 °C. During the pyrolysis of spirulina algae, the products obtained are char, liquid, and gas. These products are qualified and bio-oil properties were analyzed. The performances of a diesel engine under various injection pressure conditions i.e., 200bar and 220bar were carried out for B10 (SP10D90) and baseline diesel respectively. The consequences showed that at complete loading conditions, the maximum output power obtained while using bio-fuels is nearly the same as diesel. The consumption fuel is more when compared with diesel. The present is enhanced performance and condensed emissions by an injection pressure of 220 bars. The BTE of algae biofuels at 220bar is 28% which is close to Standard diesel along with the emission of CO, HC, and NO_X also is less compared to 200 bars and standard diesel.

KEYWORDS: Biofuel, Diesel Engine, Pyrolysis, Spirulina, Performance & Emission

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Original Article

1. INTRODUCTION

There is an increased need of transportation fuels, concerns about "peak oil", the greater effect of atmospheric CO_2, demand for energy, changes in climate, hike in the price of petroleum and depletion of fossil fuel. The microalgae have seen come into view to be the pure source of renewable bio fuel-efficient to meet energy demands [1]. The microalgae culture can be done in a particularly considered photo bioreactor. A physical and ecological factor was conventional for the proper development of society [2]. The accession of fuel by the USA and the hazards witch it has initial and a weakening towards biofuels. US has been paying$400 billion US dollars every year for the fuel they consume. To overcome this economic loss, the US has been trying to reduce the dollars they spend through some other domestically-produced renewable fuel. The emission of greenhouse gases must be controlled and thereby protect land, water, and air. The fact is all these methods have originated before billions of years and they have been considered as better methods compared to other processes. The microalgae contain 20 to 80 percent of oil by dry weight. Biomass as bio-fuel energy crops, algae production in ponds and photo bioreactors high yield, low costs lead to this exciting new feedstock for biodiesel production [3]. The bio-oil produced during the fast pyrolysis method is formed to have higher content carbon, higher calorific values, and less oxygen content compared to bio-oil produced during slow pyrolysis [4]. Comparatively more oil is produced by algae than any other oilseeds

that are in use. Accumulation of substantial quantities of lipids greater than 60% of their biomass is possible.

2. PRODUCTION OF PYRO OIL FROM MICROALGAE

Pyrolysis is a thermochemical decay of organic matter at high temperatures and oxygen’s absences. The reactor outlet is straight linked toward the condenser with a stainless steel sluice which is capable of rise superior temperature. An additional one of the bay is associated with the reactor as of the Nitrogen Cylinder. The condenser is resolutely linked with an alloy gasket. A counteract pour condenser is preferred here. The run of water is bound against the path of Pyrolysis gas. The condensate, drip addicted to the gas-liquid separator. non-condensable gas reaches the gas burner after passing during the exhaust pipe. To calculate the heat outside the reactor, a thermocouple is associated with the digital temperature gauge.

Figure 1: Experimental Setup of Pyrolysis

Utilizing the temperature adjustment switch we preserve locate the temperature point. When the particular warmth is attained, the machinery can be routinely switched inedible and the power bring is stopped to the reactor. While the warmth tends to decrease, it routinely gets switched on the power bring is functional to the reactor.

2.1 Blending of Spirulina oil with Diesel fuel

The pyrolysis of algal biomasses was studied at the warmth of 500°C in a Fluidized bed reactor [5]. Pyro oil and charcoal fuel produced from spirulina by slow pyrolysis method were analyzed. It was found that the optimum temperature to obtain pyro-oil and biochar was approximately 500 and 550°C respectively [6]. The Spirulina algae oil got by pyrolysis process at 350°C is taken and blended with diesel in proportion. The ratio is SP10D90, in volume basis of diesel fuel. The type of blending used mechanical stirrers at a speed of 800 rpm at 10 minutes. Initially, biofuel and diesel were taken in separate glass tube container then it was measured in different proportions by volume basis. The calculated amount of bio-fuel and Diesel is assorted in a jug. Mixing of the yield occurs as the fuel blend is tense during the combination of each fuel for 15 mints. The blend is worn while fueling for Diesel engine. Initially, experiment was conducted with orderly diesel fuel. Later special blend of Diesel as well as bio-fuel like SP10D90, at 200 bar and 220 bar were tested.

Figure 2: Blending of Spirulina Algae with Diesel.

2.2 Properties of Blended Oil

The below table 1 shows the distinction of density through a various blend. The table shows that densities of oil decrease through enhancing algae contents in the blend. SP10D90 shows a lower density when compared to the added oil blend. Viscosity increases using increase in blends relative amount. The calorific value of SP10D90, is nearby the same when compared to Diesel fuel. SP10D90 shows inferior calorific value while comparing to the Diesel.

Table 1: Fuel Properties of Blended Oil

Oil	Density Kg/m^3	Flash Point (C)	Fire Point (C)	Viscosity (cst)	Calorific Value (KJ/kg)
Diesel	860	51	56	3.56	42500
SP10D90	875	60	63	4.7	42037

2.3 FTIR Analysis of Spirulina Algae

The spirulina algae Pyrolysis oil obtain on a fast Pyrolysis at the temperature of 350 º C be analyze meant for its functional grouping using Fourier transform infrared spectroscopy. IR spectrum of the spirulina algae pyro-oil at optimum condition is given in figure 3. The O-H stretch vibration 3383.10 cm^{-1} along with 2728.46 cm^{-1} indicate the existence of phenol and alcohol respectively. The C-H stretch 2855.37 cm^{-1} indicates the existence of alkanes along with alkynes strong C-H stretch. 2728.46 cm^{-1} indicates carboxylic acid functional group tough extensive and O-H stretch. The C-H bending vibrations linking 1456.75 plus 1370.26 cm^{-1} are strong indicating the being there of propane. The C-O-C stretching 1115.75 cm^{-1} indicates the esters function group. C-H stretching and bending vibrations between 697.11 and 633.30 cm^{-1} indicate the occurrence of alkanes. The transmittance between 963.06 and 888.81 cm^{-1} represents C-H bending vibrations, indicative of strong alkanes. The stretching vibration from 1596.34 cm^{-1} to 778.64 cm^{-1} indicates the C-H bend, due to the presence of aromatic compounds.

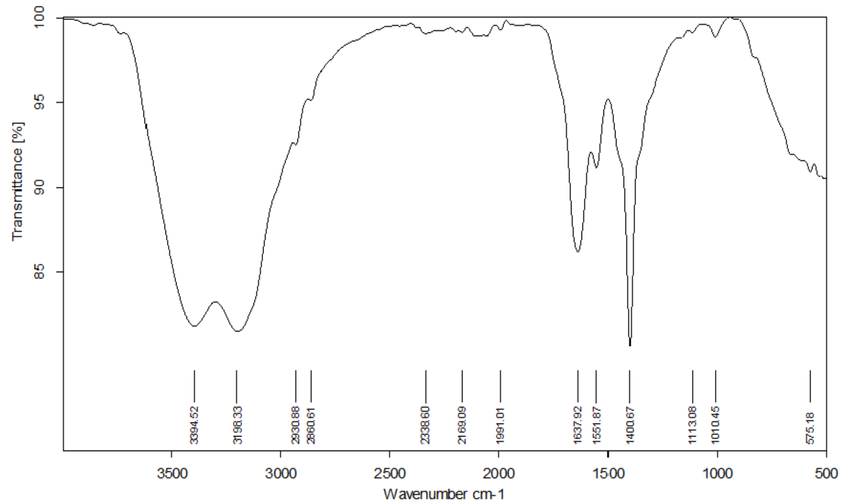

Figure 3: Spirulina Algae Pyrolysis oil FTIR Analysis.

2.4 Ultimate Analysis and Proximate Analyses

The bio-oil obtained from algae show a higher heating value (32.5-39.7Mj/kg) than that from masses (21.5-24.8Mj/kg)[6]. The ultimate analysis and proximate analysis results were calculated from Spirulina algae pyro oil. The ultimate analysis results show that all properties of SP pyro oil are closely related to that of diesel fuel.

Table 2: Ultimate and Proximate Analysis of SP oil [6]

Properties	Wt.%	Properties	Wt.%
C	39.26	moisture	8.45
H	6.11	Volatile mater	65.48
N	6.65	carbon	12.08
S	0.57	Heating value(MJ/kg)	22.34
O	47.41	Ash	13.99

2.5GC-MS Analysis of Spirulina Algae

The GC-MS analysis was used to identify and quantify lipids. Lipids are known using spectrum database software installed in GC-MS. The higher content of saturated fatty acids was observed in Spirulina algae is 76.44, it showed that major fatty acid components in all esters were carbolic acid, propane, alkanes and, linolenic acid is presented in the spirulina algae.

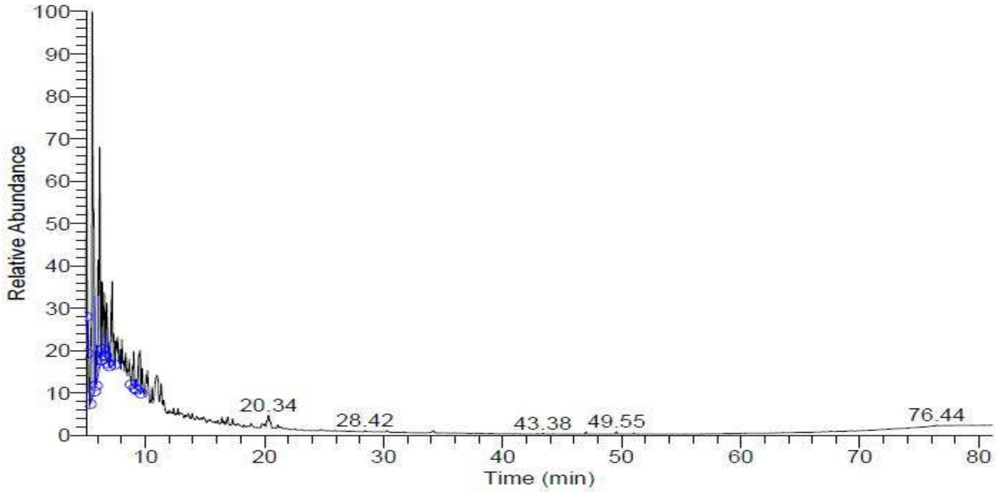

Figure 4: GC-MS Analysis of Spirulina Algae.

3. ENGINE TEST PROCEDURE

Biofuel obtained from spirulina algae pyrolysis oil gives the benefit of adding diesel with these blends and they can be presently used in the accessible diesel engine without one change. A single air-cooled cylinder, Four-stroke, diesel engine, be used as an experiment engine, it develops 5 kW at 1500 rpm. The engine is mounted on a foundation, and coupled with an Eddy current Dynamometer to convert Mechanical energy generated by the engine, directly to the system. Two systems are connected to the control and getting the signals. The first system is connected operates and controls the engine Dynamometer and the acquisition of frequency measurements. The second system measures the frequency signal, which mainly concerns the cylinder pressure, fuel injection pressure and also the angular point of the crankshaft. The pressure in the cylinder is measured by the flush on the cylinder head at a frequency of 90 kHz using a piezoelectric pressure sensor, water-cooled, type AVL transducer used. The angular position of the crankshaft was measured by an encoder placed on the flywheel.

Figure 5: Diesel Engine Setup.

4. RESULTS AND DISCUSSIONS

4.1 Engine Performance

The figures 6 show the difference in Brake thermal efficiency of Diesel and algae-diesel blends at 200 bar and 220 bar. On experimental investigation, it was found that the algae-based biodiesel fuel at 220 bar showed improved Brake thermal efficiency as well as lower Specific fuel consumption level. And also renowned that the engines that run at 200 and 220 bar by algae-based biodiesel fuels emitted lesser hydrocarbon and CO when compared to that of engine run by neat diesel [7]. An alga oil blend at 220 bars pressure increases brake thermal efficiency [8] because of better combustion. All the vegetable oil better Combustion [9-11]. The maximum efficiency of SP10D90 at 220 bars at 100% load is 30.5% which is slightly higher when compared to Diesel. There is a minor change in Brake thermal efficiency is due to lower Viscosity and slightly lesser Density content of algae bio-oil blends.

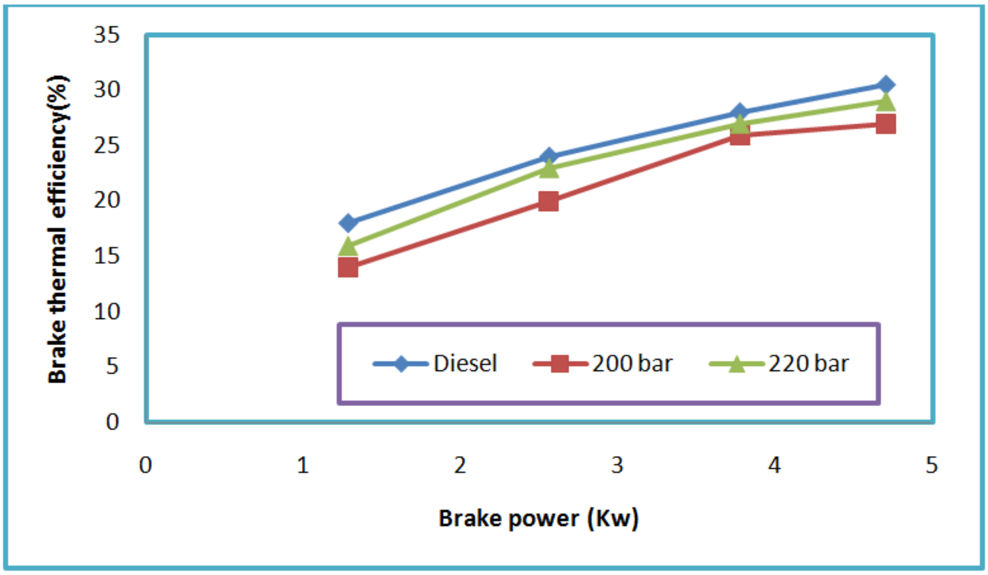

Figure 6: Variation of Brake Thermal Efficiency with Brake Power.

Figures 7 show the variation of Specific fuel consumption of Diesel, SP10D90 at 200 bar and 220 bar using brake power. It is clear from the graph, SP10D90 fuel at 220 bars showed the highest BTE, due to its better flow and higher calorific value. SP10D90 at 220 bars was observed to lower fuel consumption. It was inferred that the specific fuel consumption of SP10D90 at 200 bars was quite high when compared with neat diesel. This is because of high Viscosity and slightly high Density and small Calorific value of SP10D90 when compared to the diesel.

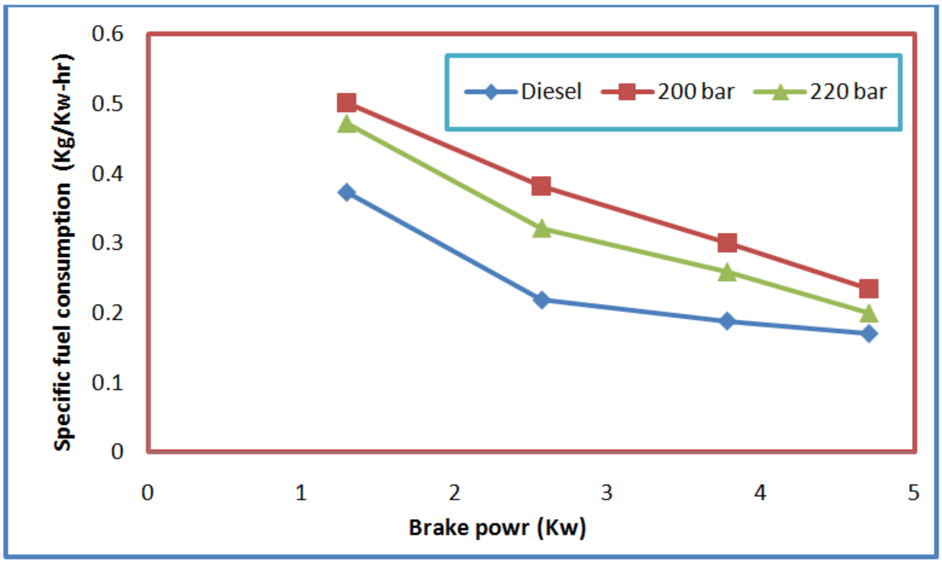

Figure 7: Variation of Specific Fuel Consumption with Brake Power.

4.2 Engine Emission Characteristics

The discharge of smoke increases by raise in Engine Power. This is owing to the rise in the quantity of fuel injected using raise in engine power. It is attractive to observe the smoke emission is create to be lesser for 220 bar at all power output as compared to the BD process. Lowest smoke emission is found through SP10D90 at 220 bars as 73 ppm. All the biofuels are reduced the smoke emission [12].

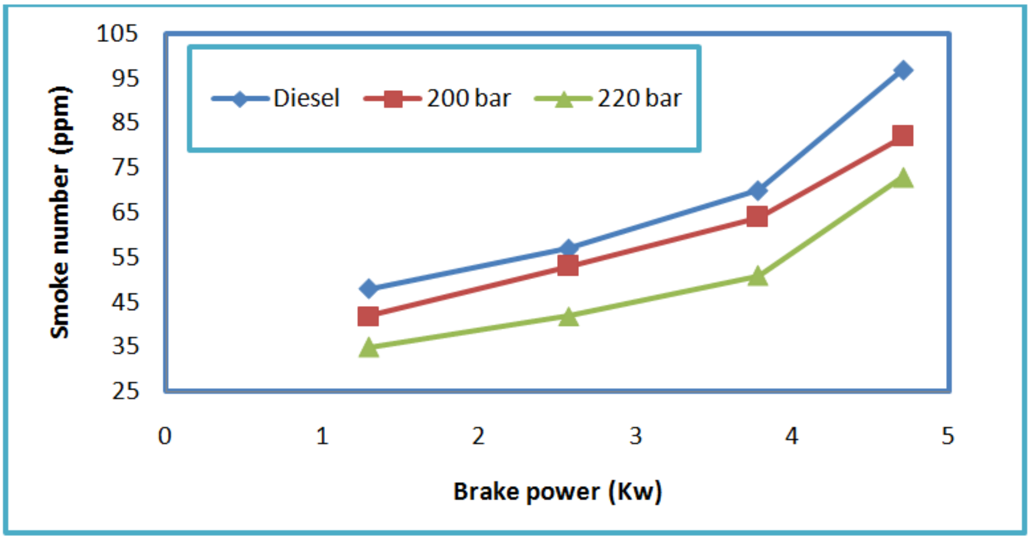

Figure 8: Variation of Smoke Opacity with Brake Power.

Diesel engine smoke formed is 97ppm, because of poor atomization of the injected fuel which causes the creation of huge droplets during the injection. Huge droplets formed because of inadequate points and are short of oxygen. Bio-oil SP10D90 at 200 bars at all power outputs resulted in increased NOx emissions as compared to BD and SP10D90 at 220 bars shown in Figure 9. The biofuel blends at SP10D90 at 220 bar resulted in increased NOx emission while comparing to diesel fuel and also water content that is presented in biofuel, resulted in increased peak cycle temperature. The higher NOx emission because of the superior warmth of the combustion chamber using conditioned biodiesel [13].

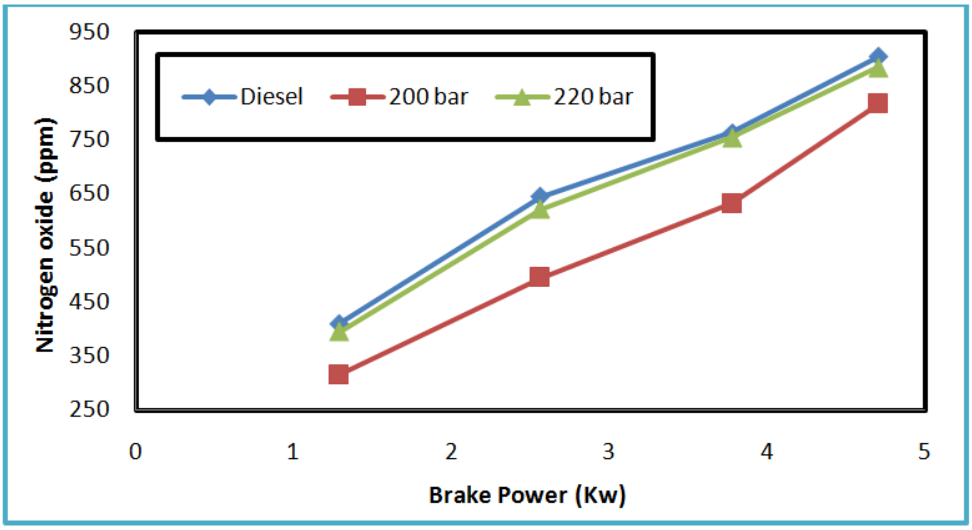

Figure 9: Variation of Nitrogen Oxide with Brake Power.

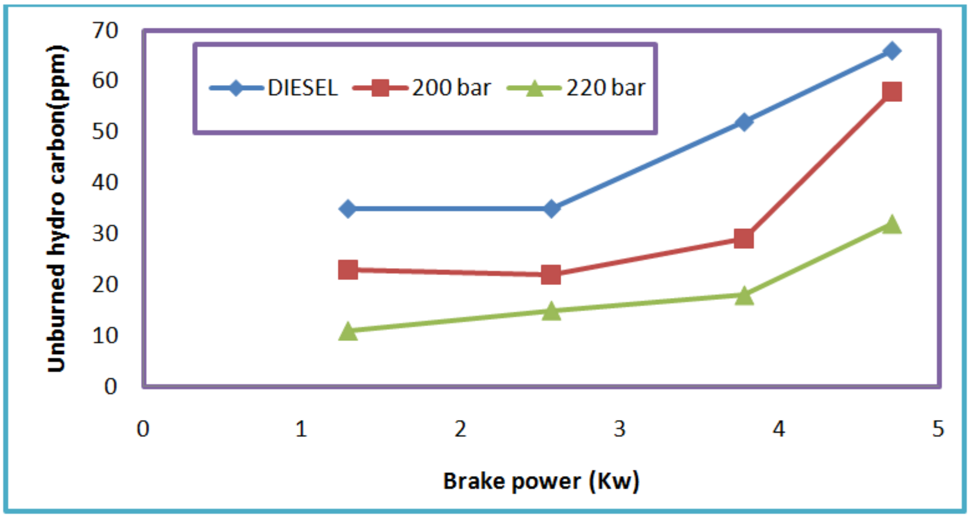

Figure 10: Variation of Unburned Hydrocarbon Emission with Brake Power.

It is seen that SP10D90 at 200 bar and 220 bar process emit minor UHC when compared to all additional fuels. An increase in the level of Oxygen that participated through combustion resolve adds to the oxidation procedure. More oxygen chemically surrounded within algae within bio-fuel which is an added source there in the intake air. Oxygen helps with the air-fuel mixture and it takes help entire combustion. The concentration of UHC into the exhaust gas increases as the amount of diesel increase in the blend. It is seen that biofuel at 220 bar test fuels resulted in lower Hydrocarbon emissions at every operating condition as compared to the base diesel process. Injection pressure, bio-oil blends results in better combustion, due to which there is a lower emission of hydrocarbon.

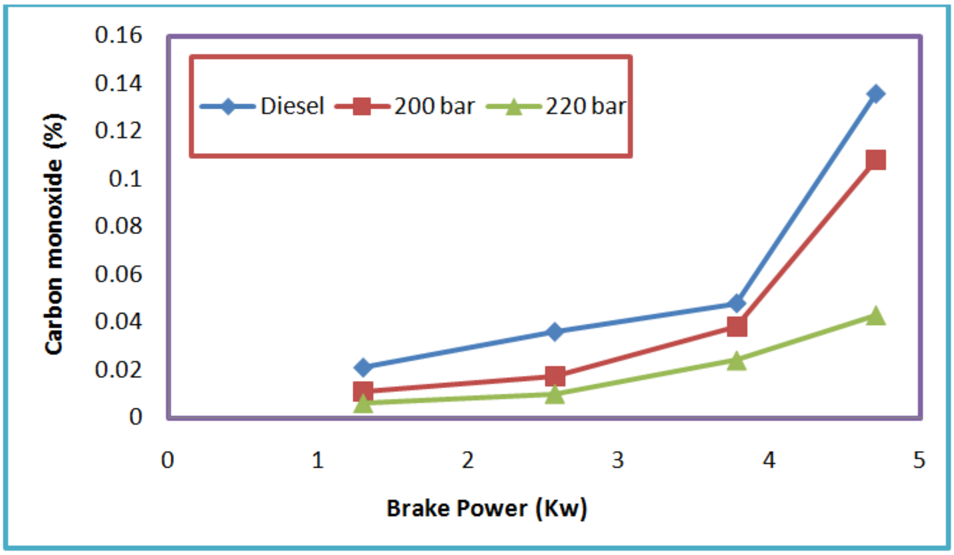

Figure 11: Variation of Carbon Monoxide Emission with Brake Power.

Figure 11 shows the outcome of carbon monoxide emissions SP10D90 at 200 and 220 bars and BD at differing power output. Every blend of bio-oil resulted in lower CO emission as compared to BD for the entire outputs. CO emission emits from in Diesel engine is higher due to the fuel riches which outcome during partial oxidization of carbon inside the fuel. It erstwhile understood to biofuel at 220 bar, emitted lower CO emission due to high oxygen bounded pyro oil blends which contributes significantly better combustion compared to biofuel at 220 bar, and SP10D90. Increasing the injector opening pressure shows major development in performance and emissions using algae oil methyl esters due to improved

spry structure [14].

5. CONCLUSIONS

The need for an alternative to petrol and diesel, the test is accepted not in the single-cylinder diesel engine and the various blend of bio-oil. The pyro oil blend SP10D90 at 200 bar and 220 bar are tried and fuel property of the above mention oils be determined. Performance and emission parameters of the efficient diesel, pyrolysis oils and their blend at 200 bar and 220 bars were evaluated. Blends of bio-oil with diesel SP10D90 at 200 bars and 220 bar resulted from incomparable performance with slight add to in Brake thermal efficiency at all power output. The brake Thermal efficiency is high with SP10D90 by 220 bars and it is reduced slightly for SP10D90 at 200 bar. The Specific fuel consumption of SP10D90 at 200 bar indicated a higher value of fuel as compared to BD. The significant drop in smoke, UHC as well as CO emission was achieved through all the blends. This is because of a better mix structure of pyro oil diesel blends. NOx emission was increased at 220 bar blends when compared to diesel fuel.

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